Evaluating Mass Analyzers as Candidates for Small, Portable, Rugged Single Point Mass Spectrometers for Analysis of Permanent Gases

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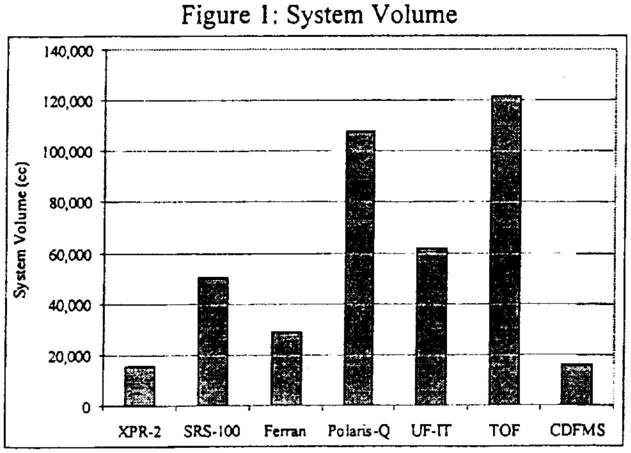
For Space Shuttle launch safety, there is a need to monitor the concentration of H_2, He, O_2 and Ar around the launch vehicle. Currently a large mass spectrometry system [1] performs this task, using long transport lines to draw in samples. There is great interest in replacing this stationary system with several miniature [2], portable, rugged mass spectrometers which act as point sensors which can be placed at the sampling point.

Five commercial and two non-commercial analyzers are evaluated. The five commercial systems include the Leybold Inficon XPR-2 linear quadrupole, the Stanford Research (SRS-100) linear quadrupole, the Ferran [3] linear quadrupole array, the ThermoQuest Polaris-Q quadrupole ion trap, and the IonWerks Time-of-Flight (TOF). The non-commercial systems include a compact double focusing sector (CDFMS) developed at the University of Minnesota [4], and a quadrupole ion trap (UF-IT) developed at the University of Florida [5].

The *System Volume* is determined by measuring the entire system volume including the mass analyzer, its associated electronics, the associated vacuum system, the high vacuum pump and rough pump. Also measured are any ion gauge controllers or other required equipment. Computers are not included. *Scan Time* is the time required for one scan to be acquired and the data to be transferred. It is determined by measuring the time required acquiring a known number of scans and dividing by said number of scans. *Limit of Detection* is determined first by performing a zero-span calibration (using a 10-point data set). Then the limit of detection (LOD) is defined as 3 times the standard deviation of the zero data set. (An LOD of 10 ppm or less is considered acceptable.)

Shown in Figure 1 is the system volume for each instrument evaluated. For reference purposes, an Alcatel 30+ turbo pump has a volume of 1200 cm^3. The most space efficient systems, the XPR-2 and the CDFMS are those that can operate using smaller backing pumps. The least space efficient system (the TOF) actually has a very small mass analyzer, but the electronics account for the bulk. The second largest system, the Polaris-Q, results from electronics and the backing pump (but in fairness, it is not meant to be a miniature system). As for the other systems, the Ferran represents an acceptable volume, the SRS-100 volume is too high primarily due to the pump required and the length of the quadrupole rods

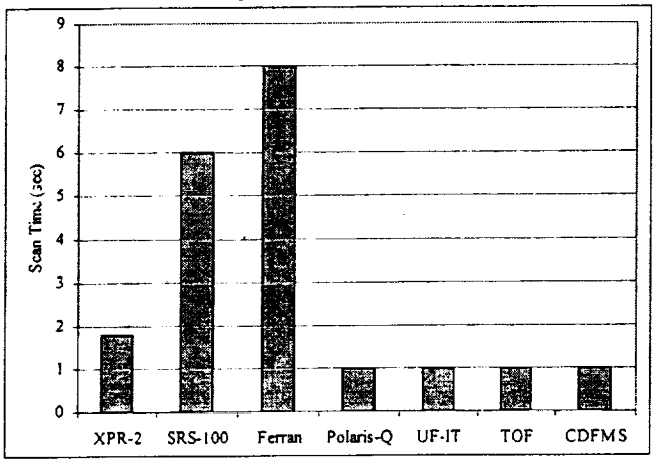
Figure 1: System Volume



and the UF-IT volume is inefficient due to the electronics, pumping requirements, and its in-house construction status.

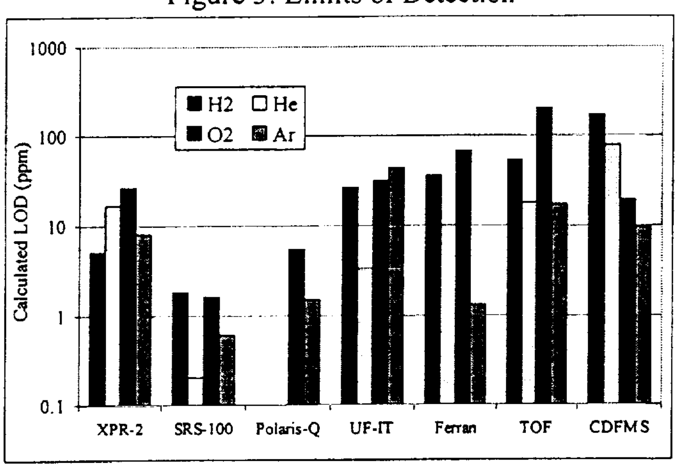
Figure 2 illustrates the scan time for each of the systems under study. Most of the systems have a scan time of 1 second. The Ferran deviates the most with a scan time of 8 seconds. The SRS-100 also has a slow scan time, 6 seconds. Both of these instruments need improvement to at least 2 seconds per scan.

Figure 2: Scan Time



The limits of detection (LOD) for each instrument are shown in Figure 3. The best instrument for LOD is the SRS-100. The XPR-2 and the UF-IT performed quite well in this category. As far as detecting O_2 and Ar, the Polaris-Q performed fine, but its mass range prevented it from detecting H_2 and He. The Ferran performed well for He and Ar, but could use improvement with H_2 and O_2. The TOF and the CDFMS need significant improvement for all of the gases.

Figure 3: Limits of Detection



With LOD receiving greater weight, and scan rate and system volume receive an equal weight and factoring in the system aspects some conclusions can be drawn. The XPR-2, SRS-100, UF-IT performed well. The Polaris-Q has problems with volume & mass range. The Ferran needs improvements with LOD and reliability. The TOF is too large and needs LOD improvements. The CDFMS needs LOD improvements

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